The Geology of the 'Glendale' Area, Near Kandos, New South Wales

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In an area centred on the rural property of 'Glendale', west of Kandos, N.S.W., Early Devonian sediments and volcanics are faulted against Late Devonian strata and are unconformably overlain by basal Permian elements of the western Sydney Basin.

The Early Devonian sequence consists of the *Yellowmans Creek Beds* (oldest), *Roxburgh Formation*, *Riversdale Volcanics* and *Carwell Creek Formation* (youngest). Late Devonian strata are the older *Buckaroo Conglomerate* and younger *Bumberra Formation*.

Permian sediments in the south of the area, are the *Megalong Conglomerate* (oldest), *Berry Siltstone*, and *Illawarra Coal Measures* (youngest).

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INTRODUCTION

Mapping centred on the 'Glendale' area near Kandos, New South Wales, has delineated an extensive explosive silicic volcanic sequence within a shallow marine, predominantly clastic Early Devonian succession; shallow marine units of the Roxburgh Formation and Carwell Creek Formation are separated by up to 890m of ignimbrite, volclitharenite, ash tuff, conglomerate and sublitharenite of the Riversdale Volcanics. These Volcanics have, elsewhere in the region, traditionally been regarded as shallow marine (Pemberton, 1977; Millsteed, 1985); however, stratigraphic, sedimentologic and textural information suggest that the Volcanics are largely a mixed subaqueous and subaerial succession.

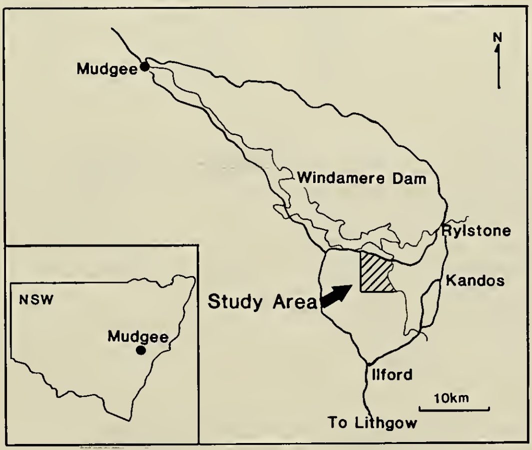

Fig. 1. Location of study area.

Previous geological investigations in the area includes the work of Sussmilch (1933) whose illustrated geological cross-sections include the 'Glendale' area and Game (1935) who interpreted the porphyries near 'Glendale' to be intrusives. More recent work in the district includes that of Pemberton (1977, 1980), Campbell (1981) , Millsteed (1985), Cook (1988) and Colquhoun (pers. comm.).

Location and Stratigraphic Framework

The 'Glendale' area is situated on the Capertee Anticlinorium (Scheibner, 1974) and contains Early Devonian strata characteristic of the Capertee High of Packham (1969). 'Glendale' lies 7km to the west of Kandos, approximately 40km SE of Mudgee and 250km NW of Sydney (Fig. 1). The sequence (Fig. 2) consists of the Yellowmans Creek Beds (Millsteed, pers. comm.), Roxburgh Formation (Pemberton, 1980), Riversdale Volcanics (Wright, 1966) and Carwell Creek Formation (Offenberg *et al.*, 1971), which is the youngest exposed Early Devonian unit. The surface geology of the 'Glendale' area is outlined in Fig. 3.

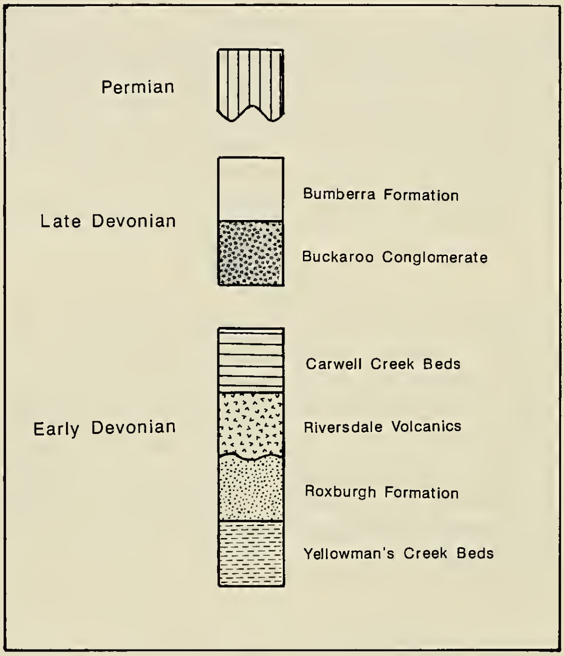

Fig. 2. Generalized stratigraphy within the study area.

The Late Devonian Buckaroo Conglomerate (Wright, 1966) and Bumberra Formation (Wright, 1966) crop-out to a subordinate extent within the study area.

The post-Devonian strata include essentially flat-lying elements of the western Sydney Basin sequence, which unconformably overlies the folded Devonian strata and consists of the Megalong Conglomerate, Berry Siltstone, and lower units of the Illawarra Coal Measures.

Stratigraphy

Yellowmans Creek Beds

The Yellowmans Creek Beds (Millsteed, pers. comm.) is the oldest unit exposed within the 'Glendale' area, cropping-out within the NE portion of the study area. The base of the unit is not seen within the study area, but a thickness of more than 340m is present. The Yellowmans Creek Beds are conformably overlain by the Roxburgh Formation.

The Beds are composed of finely-laminated shales and fine sandstones, green to brown in colour and commonly cleaved. The unit becomes slightly coarser, lighter in colour and more quartzose towards the top of the Beds. Characteristic mineralogy is

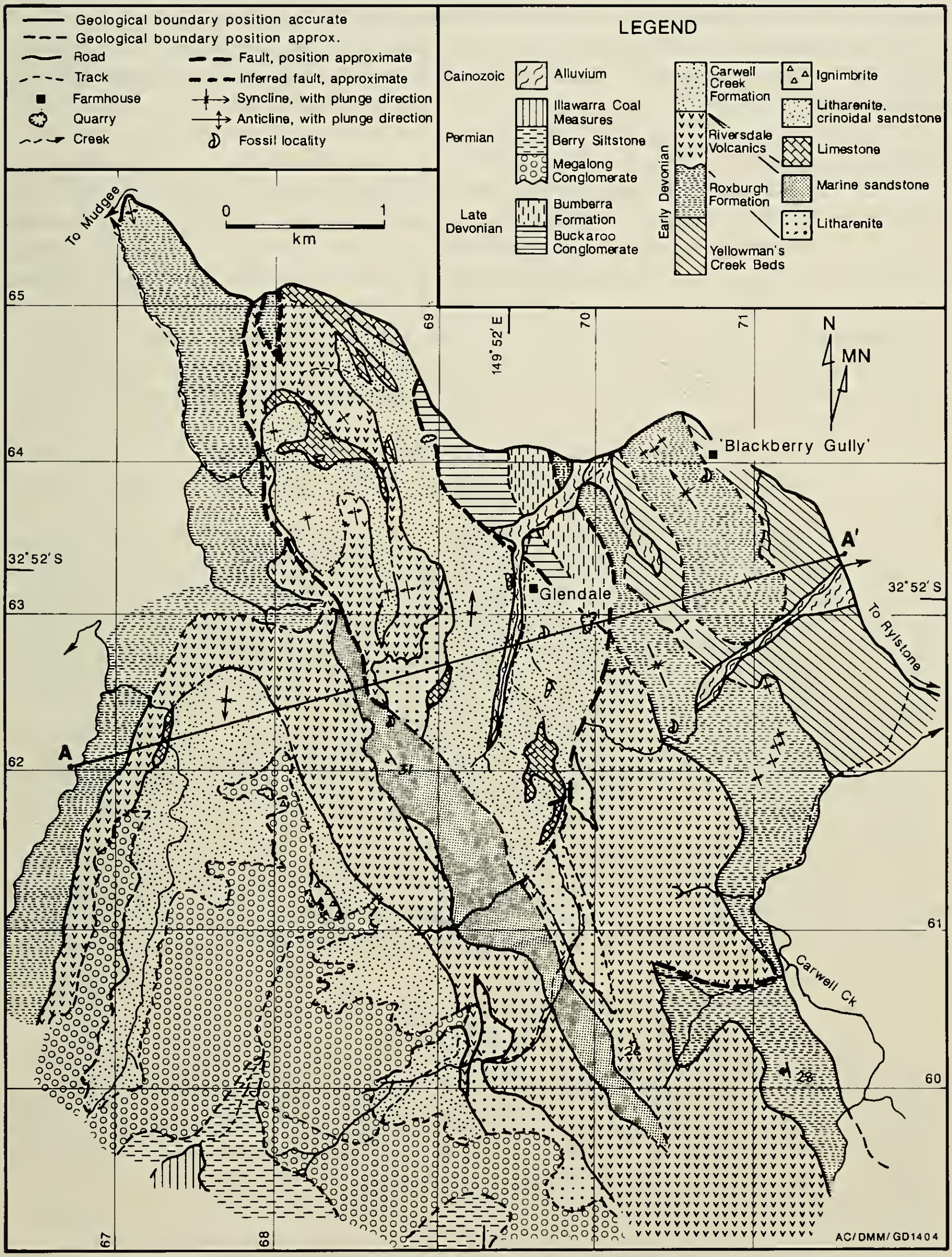

Fig. 3. Surface geology of the 'Glendale' area, showing location of cross-section A-A[1] (Fig. 5).

abundant fine-grained quartz, muscovite, chlorite and minor hematite with scattered larger quartz grains. Dark stringers of organic matter are common.

The only fauna found within this unit in the study area were a few crinoid ossicles and a fragment of an ?isorthid brachiopod. Millsteed (1985) reports a Lochkovian fauna from limestone pods within these Beds to the NW. The marine fossils, fine-grained lithology, starved asymmetrical ripple marks and parallel-laminated bedding highlight quiet marine conditions.

Roxburgh Formation

The Roxburgh Formation (Pemberton, 1980) crops-out extensively near both the eastern and the western margins of the study area. To the west the Formation, of which the base is not seen, is represented by more than 400m of strata, and this is only part of the 850 + m thick sequence originally described by Pemberton (1980); to the east the total stratigraphic thickness is 125m. The Roxburgh Formation conformably overlies the Yellowmans Creek Beds and is overlain by the Riversdale Volcanics with erosional disconformity, a relationship which may be seen in the SE of the area and has also been reported by Colquhoun (pers. comm.). It is dominated by sublitharenite, with subordinate quartzarenite, volclitharenite, conglomerate, lutite and accretionary lapilli tuff. The Roxburgh Formation has been presumed of ?Pragian age (Millsteed, pers. comm.) and this study cannot resolve the age of the Formation in the 'Glendale' area more precisely than Early Devonian.

Sublitharenites are the dominant lithology throughout the Formation and are characteristically fine- to medium-grained, cream to buff in colour, and either massive or more commonly displaying parallel-laminated bedding and low-angle tabular cross-bedding. They are typically quartz-cemented, submature, poor to moderately well-sorted and moderately close-packed, containing subrounded to subangular quartz, subrounded volcanic rock fragments, muscovite, rare K-feldspar and plagioclase grains, and traces of tourmaline, secondary sericite and chlorite.

A 2-3m thick pebble to cobble oligomictic conglomerate crops-out within the western sequence and is characterized by well-rounded dacite cobbles set in a matrix of subangular quartz, less common biotite, degraded plagioclase and abundant sericite and chlorite.

A 1-2m thick accretionary lapilli tuff horizon crops-out within the NE of the study area, providing a useful structural and stratigraphic marker near the base of the formation. Typically light brown to greenish in colour, the rock consists of abundant whole and fragmental accretionary lapilli, commonly cored by quartz anhedra, set in a fine-grained matrix.

In the western area there are a number of thin, fine-grained light coloured lutite horizons, probably representing volcanic ash deposits.

Fossiliferous shales and volclitharenites occur as common interbeds towards the top of the sequence. The litharenites contain an abundance of chloritized volcanic rock fragments. The shales are light brown in colour, prominently cleaved and contain the following fauna: *Calymene* sp. *Howellella* sp., *Iridistrophia* sp., *Leptaena* sp. and *?Delthyris* sp., as well as a number of corals, molluscs and bryozoans. In the upper western sequence massive- to poorly-bedded quartzarenite constitutes the uppermost unit of the Formation and contains limestone pebbles rich in crinoid ossicles and favositid corals.

A distinctive brachiopod fauna is developed near the base of the eastern sequence where extremely fine-grained sublitharenites are interbedded with shales containing large numbers of *Iridistrophia* sp., numerous bryozoans, favositids and carbonaceous plant remains.

The depositional environments of the Roxburgh Formation are defined by the occurrence of marine fossils, parallel-laminated bedding and low-angle cross-bedding, bioturbation and the accretionary lapilli horizon.

The lowest part of the sequence is restricted to quiet marine conditions with the accretionary lapilli horizon representing the manifestation of contemporaneous phreatomagmatic silicic volcanism. Abundant lapilli rinds imply limited reworking (Cas and Wright, 1987), but this must exclude vigorous wave action, suggesting the offshore transition zone of Reineck and Singh (1980). Higher in the sequence the sandstone becomes coarser and displays parallel-laminated bedding, low-angle tabular cross-bedding, small-scale ripples, bioturbation and pebbly horizons typical of the shoreface facies described by Reineck and Singh (1980). The uppermost western deposits of massive coarse sandstone represent upper to middle shoreface deposition, where limestone clasts from an unknown source have probably been ripped-up and redeposited by storm action.

The overall sequence is interpreted as a shallowing sequence where lower units represent deposition in the lower shoreface to transition zone (4-15m) which is overlain by lower to middle shoreface deposits (6-10m), in turn overlain by middle to upper shoreface deposits.

Riversdale Volcanics

The Riversdale Volcanics were proposed as the Riversdale Rhyolite by Wright (1966), and the name was modified by Offenberg *et al.* (1971). The Volcanics have been described by Pemberton (1980) and Millsteed (1985). The unit crops-out extensively within the 'Glendale' area and is represented by a much greater thickness than has hitherto been described. The Volcanics overlie the Roxburgh Formation with erosional disconformity; however, the erosional unconformity between the Riversdale Volcanics and the overlying Carwell Creek Formation reported by Millsteed (1985), was not observed within the 'Glendale' area. The total composite thickness of the Riversdale Volcanics, including discontinuous sandstone bodies, amounts to 1250m; however the maximum outcrop thickness is 890m. This differs from the 200m and 320m reported by Pemberton (1980) and Millsteed (pers. comm.) from areas to the W and N respectively.

Mapping within the 'Glendale' area has refined the stratigraphy of the Riversdale Volcanics, allowing recognition of seven mappable lithologies (Fig. 4); these are basal conglomerate, volcanic ash unit, three volclitharenite units, a sublitharenite unit and the dominant ignimbrite series, of at least five individual units. No lavas were found within the Riversdale Volcanics.

Basal Conglomerate

This poorly outcropping unit occurs at the base of the Volcanics, having its best exposure, and maximum thickness of 25m in the southeast of the study area. In the western portion of the study area the unit is very poorly developed, with a maximum thickness of 2m.

In the east the unit is a crudely bedded, matrix-supported, volcanilithic conglomerate, consisting of subrounded to subangular cobbles of rhyodacite set in volcanilithic sand matrix. There is patchy development of breccia horizons, with angular clasts up to 75cm in size. In the west the conglomerate is characterized by rounded sublitharenite clasts and subangular clasts of rhyodacite, supported in a fine lithic sand matrix.

Rounded sandstone clasts in the west suggest reworking of units of the Roxburgh Formation.

Volcanic Ash Unit

A fine-grained cream to pink coloured ash unit occurs near, or at the base of, the Riversdale Volcanics. At some localities the ash unit can be observed above the conglomerate, whereas at others the ash unit occupies a basal position on top of the Roxburgh Formation. It has a maximum thickness of 2m but is typically around 1m thick. Outcrop is poor but widespread. The ash unit is mostly composed of irresolvable fine grains, thought to be devitrified glass shards, displaying microbedding structures. Accretionary lapilli up to 12mm in diameter are common.

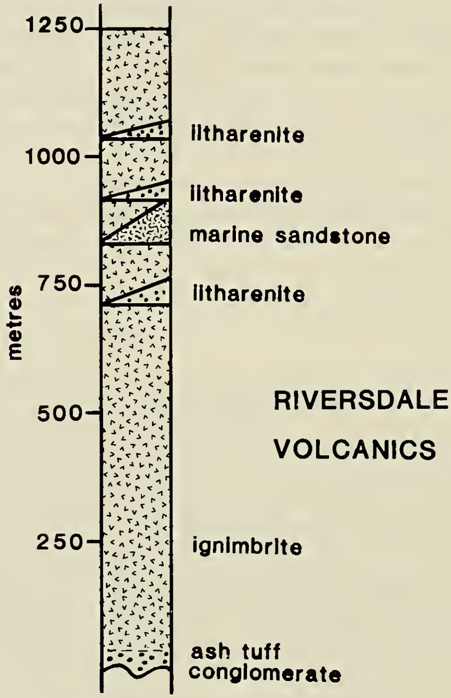

Fig. 4. Detailed stratigraphy of the Riversdale Volcanics.

Ignimbrite Series

The Riversdale Volcanics are mostly comprised of large thicknesses of ignimbrites; however, individual flow units cannot be positively identified, but they are at least 10m in thickness, as shown by the vertically continuous welding of more than 10m of sequence. These ignimbrites vary from hard, deep-purple, strongly welded tuff to somewhat weathered, grey-green, non-welded units, which have a distinctive jagged outcrop pattern. Commonly large stretched out fiamme are distinguishable in outcrop and hand specimen.

The ignimbrites consist of cognate rhyodacite fragments, flattened pumice lapilli, and abundant broken phenocrysts of quartz and feldspar, in a fine-grained dark groundmass. Rhyodacite fragments are up to 50mm in size, and are typically angular. Pumice lapilli, commonly replaced with carbonate and sericite show relict vesiculation and ragged wispy ends; they are difficult to distinguish from the groundmass in thin section and are best seen in weathered hand specimens, where they are up to 60mm long. Phenocrysts of quartz are fractured and embayed, everywhere anhedral and are up to 2mm in size. Subhedral to rare euhedral plagioclase (An = 7-10%) phenocrysts, up to 3mm are typically broken and display relict twinning and sporadic zoning.

Subordinate K-feldspar subhedra occur and are commonly twinned. Both feldspar phases are highly altered to sericite and carbonate. Trace opaque oxides occur sporadically.

The groundmass consists of devitrified glass shards or irresolvable fine ash. The shards appear as foliated and welded fragments showing alteration to microcrystalline quartz and feldspar, and whereas relict eutaxitic texture is obvious in welded samples, shards now show pin-point birefringence as a response to devitrification. Within non-welded samples the groundmass is exclusively fine ash.

Using the component criteria of Cas and Wright (1987), the ignimbrites are classified as welded vitric tuffs with subordinate non-welded vitric tuffs; their mineralogy suggests a rhyodacitic source. No textures suggestive of lavas were found within the sequence.

Arenite Units

Three discrete, large lenticular volcaniclastic bodies and a number of much smaller lenses occur within the Riversdale Volcanics. Individual units show great variation in thickness, and lens out over several hundred metres. In outcrop the units appear as medium- to coarse-grained, commonly pebbly, 'dirty' sandstones. Low-angle crossbeds are sometimes discernible in places. Volclitharenites are clast-supported, poorly sorted and immature. They contain angular to subrounded quartz, relict pumice lapilli, devitrified glassy fragments, feldspars and abundant volcanic clasts set in an extremely fine-grained groundmass representing devitrified ash. Carbonate is a common cement and alteration phase, as are chlorite, hematite and sericite.

A distinct thick, but lensoidal arenite unit is found within the Riversdale Volcanics, approximately two-thirds up into the sequence (Fig. 4). It differs markedly from other arenite units within the Volcanics in being cleaner. much lighter in colour, and massive to well-bedded. As it contains sporadic limestone pebbles, is bioturbated in places, and is far more quartzose than other arenites within this formation, it strongly resembles elements of the Roxburgh Formation; however, it contains far more volcanic detritus and is clearly conformable within the Volcanics. In thin-section it is a fine- to medium-grained, closely packed sublitharenite containing subangular to angular quartz, subrounded to subangular volcanic rock fragments and traces of muscovite, sericite, opaques and chlorite. Crinoid ossicles, an unidentified mollusc and the brachiopod *Iridistrophia* sp. were collected from this arenite unit.

Depositional Environment

The basal conglomerate and breccia beds of the Riversdale Volcanics suggest a slight to moderate reworking of volcanic and underlying detritus. The sparse distribution, variable thickness and the erosional contact suggest deposition of this unit in erosional hollows; however there are no identifiable trough structures to substantiate this view.

The presence of abundant whole accretionary lapilli within the ash unit negates extensive reworking of this unit. Such lapilli would be easily destroyed in water and, given the shallow environment of the upper Roxburgh Formation and the erosional base to the volcanics, this suggests subaerial deposition. The accretionary lapilli also indicate the presence of water vapour within the eruption column or storms associated with the eruption clouds (Cas and Wright, 1987).

Pemberton (1977, 1980) and Millsteed (1985) infer a subaqueous environment for the Riversdale Volcanics on the basis that the underlying and overlying strata are shallow marine. Deposition of such thick welded ignimbrites would have filled and exceeded the water depths of the shoreface environments of the Roxburgh Formation. Unless deposition of the units was accompanied by very rapid subsidence then, with commonly more than 10m of ignimbrite present, it is most likely that the ignimbrites are in the main subaerial. This conclusion is supported by the erosion surface and the nature of the ash layer. It is also supported by the abundance of welding textures throughout the Volcanics. Whilst welding can occur in shallow marine environments, it is generally only found in extremely shallow depths (Cas and Wright, 1987).

It is considered that steady subsidence continued throughout deposition of this formation, and that the marine sandstones are a result of this. Low-angle cross-bedding, and parallel laminated bedding, combined with limited bioturbation and the presence of limestone pebbles, suggest a shoreface environment for deposition of the sublitharenite unit. Above this unit thick ignimbrite deposition suggests further subaerial exposure.

The volclitharenite units within the Riversdale Volcanics offer little evidence for environmental interpretation. They are poorly-bedded and in places cross-bedded, and clast roundness suggests some reworking.

In summary, initiation of the Riversdale Volcanics began with the deposition of volcanically-derived conglomerates, overlain by a thin, probably subaerial ash fall unit. These were covered by an extensive sequence of subaerial silicic pyroclastic flows. Continual subsidence led to the deposition of a shallow-marine sand body during quiescence, and volclitharenite units accumulated between eruptive episodes from reworking of volcanic detritus.

Carwell Creek Formation

The Carwell Creek Formation crops-out extensively within the study area and consists of 280m of limestone, crinoid-rich sandstones, lithic sandstones and minor ignimbrite units. Originally defined as the Carwell Creek Beds (Offenberg *et al.*, 1971) the definition of a lower boundary (Pemberton, 1980; Millsteed, pers. comm.; and this work) and an upper stratigraphic boundary (Millsteed, pers. comm.) warrants the elevation of this unit to Formation status.

The basal part of the Carwell Creek Formation is characterized by a thin discontinuous impure limestone unit which has been informally named the 'Upper Kandos Limestone' (Cook, 1988; Pemberton, pers. comm.). The limestone attains a maximum thickness of 25m and is dominated by recrystallized microsparite and lesser pelsparite containing variable amounts of quartz grains (3-10%). Within northwestern exposures of the unit, the lithology is slightly more fossiliferous containing sporadic favositid and stromatoporoid fragments. Shale interbeds are exposed within disused quarries in the NW of the study area and fenestral textures to the limestone suggest intertidal exposure. The basal limestone is in part overlain by a distinctive sublitharenite unit which, at its base, is rich in crinoid ossicles. This variable lithology is mostly restricted to the central portions of the study area, and grades vertically into litharenite units which dominate the Carwell Creek Formation. Sedimentary structures within these units include tabular cross-bedding, planar bedding and rare pebbly lags, in addition to burrows. These crinoidal sandstones consist predominantly of fossil fragments, (decreasing in abundance with stratigraphic height), quartz grains and angular volcanic rock fragments cemented predominantly by ferroan-calcite with minor dolomite. The upper parts of this unit contain fewer crinoid fragments and are somewhat more quartz-rich.

Volcanic-rich sandstone beds dominate the Carwell Creek Formation, forming the bulk of the formation. These are poorly bedded, medium-grained, immature litharenites composed of abundant volcanic rock fragments, quartz grains and lesser amounts of degraded feldspars. Tabular cross-beds are common, as are pebbly horizons. A thin, discontinuous, highly siliceous ignimbrite unit found in the uppermost Carwell Creek Formation is similar to unwelded tuffs described from the Riversdale Volcanics.

Low-angle tabular cross-beds and parallel-laminated beds suggest similar marine environments to those of the Roxburgh Formation. Carbonates were deposited in extremely shallow, possibly intertidal, shoals. Upper litharenite units provide little evidence for environmental interpretation. The upper ignimbrite highlights continuation of silicic volcanism during this time.

Depositional Sequence of Early Devonian Strata

The Early Devonian succession within the 'Glendale' area begins with the shallow, quiet, marine deposition of shale and fine sandstone of the Yellowmans Creek Beds. The lowermost Roxburgh Formation represents continuation of these conditions, eventually giving way to the coarser, shallower deposits which form the bulk of the Roxburgh Formation. Following an episode of erosion, evidenced by the erosional unconformity at the base of the Riversdale Volcanics, volcanic conglomerate heralded substantial silicic volcanic activity. The lower ash unit of the Riversdale Volcanics shows no evidence of substantial reworking, and subsequent ignimbrite deposition was probably subaerial. Minor shallow marine sublitharenites, are followed by continuation of ignimbrite deposits. A southerly source for the volcanics is indicated by a thinning of the Volcanics to the north, west and northeast (Pemberton, 1980: Millsteed, 1985; Colquhoun, pers. comm.). The transgressive Carwell Creek Formation was deposited in shoreface environments.

Significant hiatus and angular discordance between Early and Late Devonian units has been demonstrated by Millsteed (1985), but within the 'Glendale' area the boundary is faulted.

Late Devonian Strata

Late Devonian strata crop-out in a faulted block in the central north of the study area and consist of elements of the Buckaroo Conglomerate (Wright, 1966) and Bumberra Formation (Wright, 1966). Represented by a 150m thick unit, the Buckaroo Conglomerate consists of a coarse polymictic conglomerate, dominated by pebble- to cobble-sized, rounded clasts of quartzite, chert, quartz, volcanic and metamorphic rock fragments set in a sand-size quartz-lithic matrix. Its restricted exposure prevents accurate assessment of depositional environment; however, its coarse-grained rounded clasts supports Millsteed's (1985) view of fluvial deposition. The Late Devonian sequence is transgressive through a transitional series of mixed conglomerate-marine sandstone interbeds containing a sparse brachiopod fauna, to the marine Bumberra Formation. These units are quartz-rich, fine- to medium-grained sublitharenites, displaying parallel laminated bedding, shallowly-dipping tabular cross-beds and sporadic bioturbation. The Bumberra Formation is faulted against the Roxburgh Formation (Fig. 3).

Permian Strata

Essentially flat-lying Permian strata unconformably overlie the Devonian rocks in the south of the study area and are represented by 35m of Megalong Conglomerate, approximately 30m of Berry Siltstone and about 80m of Illawarra Coal Measures (Clarke, 1866). The Megalong Conglomerate (McElroy *et al.*, 1969) is a coarse cobble to boulder polymictic conglomerate, containing quartzite, chert, volcanic and polycrystalline quartz clasts set in a quartz-lithic matrix. Coarse sand horizons define broad trough structures, supporting the long-held view of a fluvial origin for the Megalong Conglomerate (Dulhunty and Packham, 1962). This is further evidenced by the irregularities in unit thickness, a response to the palaeorelief at the base of the unit. The Megalong Conglomerate is overlain by fine siltstones of the Berry Siltstone (David and Stonier, 1890), which contain common boulder erratics suggesting possible glacial rafting during deposition. The Illawarra Coal Measures commence with a light coloured oligomictic conglomerate, the Marrangaroo Conglomerate (Stephens, 1883), which is in turn overlain by poorly exposed, fine-grained siltstone, sandstones and shales forming the remainder of the incomplete section.

Structure

Devonian strata within the study area have been deformed into gentle upright synclines and anticlines which, in general, trend N-NW (330-350°) and plunge shallowly at 1-14°. A few major folds have shallow southerly plunging axes. All folds have upright axial surfaces and are asymmetrical with steeper limbs to the west. They are open with interlimb angles between 130 and 170°. The overall fold pattern defines a small synclinorial zone trending SE-NW with a plunge of 1-2° to NW. A representative cross-section through the area is given below (Fig. 5).

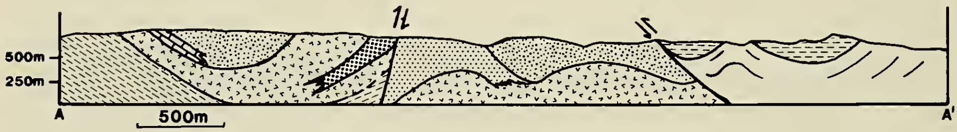

Fig. 5. Cross-section A-A[1] through study area. No vertical exaggeration. Legend as per Fig. 3, except Yellowmans Creek Beds (unshaded).

Mesoscopic folds are well developed in the well-bedded Yellowmans Creek Beds and Roxburgh Formation, possessing upright axial surfaces and rounded hinges, and are generally open with interlimb angles from 100-130°. They have no apparent asymmetry. In the NE of the area slightly more intense folding highlights the thinning of the Riversdale Volcanics and a well-developed, near-vertical axial planar cleavage is present, striking NW.

Three major faults occur in the 'Glendale' area. To the N of 'Glendale' farmhouse the Carwell Creek Formation is normally faulted against the Late Devonian Buckaroo Conglomerate. Millsteed (1985) interpreted this fault, to the immediate N to lie on the unconformity between Early and Late Devonian strata and as such represents some minor stratigraphic throw. To the immediate E, the Roxburgh Formation is thrust against the Bumberra Formation. Similarities of lithology between the Roxburgh Formation and the Bumberra Formation prevent accurate calculations of the displacement on this fault. It is clear, however, that there is some considerable strike slip component to both these faults. The third major fault extends from the NW of the study area, SE principally through the Riversdale Volcanics. To the W of 'Glendale' the fault is represented by an extensive cleavage zone through the Volcanics, whilst to the immediate S of 'Glendale' the Riversdale Volcanics are thrust over the Carwell Creek Formation revealing a net stratigraphic displacement in the order of 100-200m.

The stratigraphic discontinuities of sandstone beds within the Riversdale Volcanics in the creek S of the farmhouse can be rationalized in terms of an extension of the Roxburgh Formation-Bumberra Formation thrust. Thus the central portion of the study area is seen as a fault slice. Unlike the other fault systems within the study area, which are expressed as a string of ironstone quarries defining brecciated zones, the latter is an inferred fault defined on the basis of stratigraphic discontinuities within the 'Glendale' valley. Minor cross cutting faults are common in the study area.

Geological History

The Capertee High had risen by the mid-Silurian (Jones *et al.*, 1987) in response to dextral transtension along the then eastern margin of the Lachlan Fold Belt (Powell, 1984).

Early Devonian strata within the 'Glendale' area represent continuation of deposition on the Capertee High, with initial deposition of shallow-marine shales and sandstones of the Yellowmans Creek Beds. Continuing shallow-marine deposition was coupled with manifestations of phreatomagmatic silicic volcanism, as evidenced by accretionary lapilli tuff within the Roxburgh Formation. Shallow-marine transition to shoreface conditions were responsible for the deposition of the Roxburgh Formation.

Following a period of subaerial exposure and erosion, the deposition of coarse volcaniclastics and volcanic ash heralded the substantial silicic volcanism of the Riversdale Volcanics; the resulting thicknesses of ignimbrite were deposited from a southerly source in a predominantly subaerial environment. Shallow-marine sandstones within the Volcanics represent minor transgressive marine influences during periods of quiescence. The Carwell Creek Formation was deposited in response to continued subsidence, again in a shallow-marine environment. Minor silicic volcanism continued to provide detritus and minor ignimbrite during deposition. Following the hiatus associated with mid-Devonian tectonic movements, as discussed by Powell and Edgecombe (1978) and Millsteed (1985), the Late Devonian Buckaroo Conglomerate was deposited in a fluvial environment. Further marine transgression resulted in the deposition of the Bumberra Formation. The Lawson's Creek Shale (Wright, 1966) is not present within the study area due to faulting, but has been identified by Millsteed (pers. comm.) to the immediate N.

Timing of the major deformation within the 'Glendale' area is post-Devonian, pre-Permian and is best attributable to the Kanimblan Deformation, as discussed by Powell *et al.* (1976), which has had such a profound effect on the northern Lachlan Fold Belt.

Permian strata represent deposition at the margins of the western Sydney Basin and show possible glacial influence at the base.

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References

CAMPBELL, J. C., 1981. — The geology of an area between Rylstone and Cudgegong, N.S.W. Wollongong, N.S.W. University of Wollongong B.Sc. (Hons.) thesis, unpubl.

CAS, R. A., and WRIGHT, J. V., 1987. — *Volcanic Successions: Modern and ancient.* London: Allen and Unwin.

CLARKE, W. B., 1866. — On the occurrence and geological position of oil-bearing deposits in New South Wales. *Quart. J. Geol. Soc. Lond.* 22: 439.

COOK, A. G., 1988. — The geology of the Glendale Area, near Kandos New South Wales. Wollongong, N.S.W.: University of Wollongong B.Sc. (Hons.) thesis, unpubl.

DAVID, T. W. E., and STONIER, G. A., 1890. — Appendix 2J. Report on the coal measures of the Shoalhaven District, and on a bore near Nowra. *Ann. Rep. Dep. Min. N.S.W.*, 244.

DULHUNTY, J. A., and PACKHAM, G. H., 1962. — Notes on Permian sediments in the Mudgee district, N.S.W. *J. Proc. R. Soc. N.S.W.* 95: 161-166.

GAME, P. M., 1935. — The geology of the Cudgegong district. *J. Proc. R. Soc. N.S.W.*, 68: 199-233.

JONES, B. G., CHENHALL, B. E., WRIGHT, A. J., PEMBERTON, J. W., and CAMPBELL, C., 1987. — Silurian evaporitic strata from New South Wales, Australia. *Palaeo., Palaeo., Palaeo.* 59: 215-225.

MCELROY, C. T., BRANAGAN, D. F., RAAM, A., and CAMPBELL, K. S. W., 1969. — Shoalhaven Group *In* PACKHAM, G. H. (ed.) The geology of New South Wales. *J. Geol. Soc. Aust.* 16: 357-370.

MILLSTEED, B. D., 1985. — The geology of an area to the north-east of Cudgegong, N.S.W. Wollongong, N.S.W.: University of Wollongong B.Sc. (Hons.) thesis, unpubl.

OFFENBERG, A. C., ROSE, D. M., and PACKHAM, G. H., 1971. — Dubbo 1:250 000 geological series, sheet SI 5504. *Geol. Surv. N.S.W.*

PACKHAM, G. H. (ed.), 1969. — The geology of New South Wales. *J. Geol. Soc. Aust.* 16.

PEMBERTON, J. W., 1977. — The geology of an area near Cudgegong, Central Western New South Wales. Wollongong, N.S.W.: University of Wollongong B.Sc. (Hons.) thesis, unpubl.

——, 1980. — The geology of an area near Cudgegong, New South Wales. *J. Proc. R. Soc. N.S.W.* 113: 49-62.

POWELL, C. MCA., EDGECOMBE, D. R., HENRY, N. M., and JONES, J. G., 1976. — Timing of regional deformation of the Hill End Trough: a reassessment. *J. Geol. Soc. Aust.* 23: 407-421.

——, and EDGECOMBE, D. R., 1978. — Mid-Devonian tectonic movements in the northeastern Lachlan Fold Belt. *J. Geol. Soc. Aust.* 25: 165-184.

REINECK, M. E., and SINGH, I. B., 1980. — *Depositional Sedimentary Environments.* Berlin Springer-Verlag.

SCHEIBNER, E., 1974. — Lachlan Fold Belt: definition and review of structural elements. *In* MARKHAM, N. L., and BASDEN, H. (eds.) *The Mineral Deposits of New South Wales.* Sydney. Geol. Surv. N.S.W.

STEPHENS, W. J., 1883. — Notes on the geology of the western coalfield. Part 1. *Proc. Linn. Soc. N.S.W.*, 7: 548.

SUSSMILCH, C. A., 1933. — The Devonian strata of the Kandos district, New South Wales. *J. Proc. R. Soc. N.S.W.*, 67: 206-233.

WRIGHT, A. J., 1966. — Studies in the Devonian of the Mudgee district, N.S.W. Sydney: University of Sydney Ph.D. thesis, unpubl.